

## **Retrofittable Power Supply**

### **Technical Field:**

The technical field is power supplies for electrical and electronic devices, and in particular, wireless power supplies for powering electronic devices such as personal computers.

### **Background:**

Many electrical and electronic devices cannot be used in certain geographical regions because of the absence of AC or DC power to operate the devices. Other electronic or electrical devices are restricted geographically because the power supplies in these devices do not conform to the available power in terms of voltage and/or frequency. One solution is to produce portable versions of the electrical and electronic devices that can operate on self-contained power supplies, such as nickel-cadmium batteries or the like. Recently, fuel cell technology has been adapted to provide power for the portable electronic devices. U.S. Patent 6,057,051 discloses a miniaturized fuel cell assembly that can be adapted for use in a portable, or laptop computer. U.S. Patent 5,759,712 discloses a miniature fuel cell that can be adapted to a variety of purposes to power portable electronic devices, such as cellular telephones.

The above-noted patents disclose solutions for powering portable electronic devices. Because they are intended to be portable, the electronic devices must be designed to include specific features, such as light weight, small size, and most importantly, low power consumption. Thus, the design of a portable electronic device necessarily considers the availability of a power supply that can fit the device's design parameters of light weight and small size, and yet can deliver sufficient power to operate the device for a sustained period. Such design constraints (portability, low power consumption) often lead to lower performance capabilities compared to corresponding non-portable devices, and to greatly increased costs of manufacture.

While electrical and electronic devices that are not designed to be portable (including design limits on power consumption) cannot be used in geographical regions where power is unavailable, these non-portable devices also are generally less expensive to manufacture, and provide for better performance than their portable counterparts. For example, a desktop personal computer may operate at a higher clock speed, have a larger memory and mass storage, and cost less, than a laptop, or portable personal computer. Thus, achieving the best performance at the lowest cost is not consistent with the concept of portability.

1 **Summary:**

2 A retrofittable power supply allows an electronic device that is initially designed  
3 to be non-portable (in the sense that such electronic and electrical devices require a wired  
4 connection to an AC or DC power supply) to operate in geographical regions, or under  
5 conditions, in which a wired power supply is not available. The retrofittable power  
6 supply can simply plug into an existing case or frame of the non-portable electronic  
7 device, and can then serve as a means for powering both the non-portable electronic  
8 device, as well as a means for powering peripheral devices that may be coupled to the  
9 non-portable electronic device.

10 In an embodiment, the retrofittable power supply comprises a housing having a  
11 form factor equivalent to a conventional, wired power supply. The housing includes a  
12 power generation section. The power generation section may comprise a fuel cell, or  
13 otherwise incorporate advanced fuel cell technology. The power generation section may  
14 include, as part of the fuel cell, a water holding and disposal module. The water holding  
15 and disposal module may comprise water absorption means, which may include  
16 commercially available materials that absorb and hold water generated by the fuel cell.  
17 The water holding and disposal module may also include a water tank to hold excess  
18 water generated by the fuel cell. The water holding and disposal module may also  
19 include means for disposal of excess water. In an embodiment, the water disposal means  
20 comprises a fan that accelerates evaporation of the excess water. Alternatively, or in  
21 addition, heat generated by operation of the fuel cell may be used to speed evaporation.  
22 In another embodiment, excess water may be drained from the water holding and disposal  
23 module. Such drainage may be facilitated by a manually or automatically operated valve,  
24 and a piping arrangement that diverts the draining water from components of the non-  
25 portable electronic device.

26 The retrofittable power supply may also comprise DC/AC power converter to  
27 supply AC power. The AC power may be supplied at one or more AC power out fixtures  
28 to enable operation of peripheral devices associated with the non-portable electronic  
29 device.

30 In another embodiment, the retrofittable power supply may include a power  
31 storage module. The power storage module may be a rechargeable battery, for example.  
32 The power generation module then provides DC power to the power storage module for  
33 subsequent delivery to one or more components of the non-portable electronic device or  
34 to one or more peripheral devices.

1 A specific application of the retrofittable power supply is to replace a  
 2 conventional, wired power supply in a desktop personal computer. The conventional,  
 3 wired power supply is simply removed, and is replaced by the retrofittable power supply.  
 4 The AC power out section of the retrofittable power supply provides AC power to  
 5 peripheral devices such as a monitor and a printer, for example. When using a fuel cell in  
 6 the power generation module, the fuel source will eventually have to be replenished. This  
 7 may be accomplished by replacing the entire retrofittable power supply with a new  
 8 retrofittable power supply. Alternatively, a fuel supply in the fuel cell may simply be  
 9 renewed. For example, in a fuel cell using liquid methanol carried in a fuel tank, the tank  
 10 can be refilled or simply replaced.

11 Other power sources besides fuel cells may be used in the power generation  
 12 module. For example, the power generation module may use a radioactive material, such  
 13 as plutonium 239, to generate heat energy, which is then converted into electrical energy.  
 14 Other possible power generation means can include small turbines or solar devices.  
 15 Power storage means may include, in addition to conventional batteries, fly wheel storage  
 16 devices, and devices that convert the heat generated by operation of the fuel cell into  
 17 electrical power for subsequent storage.

#### 18 **Description of the Drawings:**

19 The detailed description will refer to the following drawings, in which like  
 20 numerals refer to like items, and in which:

21 Figure 1 illustrates a typical non-portable electronic device having a conventional  
 22 wired power supply;

23 Figure 2 illustrates the conventional wired power supply from the non-portable  
 24 electronic device of Figure 1;

25 Figure 3 illustrates a retrofittable power supply adaptable to replace the  
 26 conventional power supply shown in Figure 2;

27 Figure 4 is a cross sectional view of the retrofittable power supply of Figure 3;  
 28 and

29 Figure 5 illustrates an alternative retrofittable power supply adapted for use with  
 30 the non-portable electronic device of Figure 1.

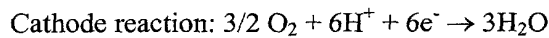
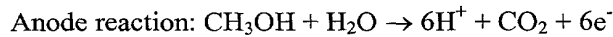
#### 31 **Detailed Description:**

32 To provide non-wired power to a non-portable device, a retrofittable power supply  
 33 uses a same form factor as an existing conventional, wired power supply used in the non-  
 34 portable device. The non-portable device may be a desktop personal computer, for

example. In an embodiment, the retrofittable power supply may use fuel cell technology to generate DC power. Alternative means for developing power include devices or materials that generate heat, which can subsequently be converted to electrical energy. An example of such a heat-generating material is plutonium 239. Other devices for generating electrical power include a solar power device and a wind turbine.

A fuel cell is an electrochemical apparatus wherein chemical energy generated from a combination of a fuel with an oxidant is converted to electric energy in the presence of a catalyst. The fuel is fed to an anode, which has a negative polarity, and the oxidant is fed to a cathode, which, conversely, has a positive polarity. The two electrodes are connected within the fuel cell by an electrolyte to transmit protons from the anode to the cathode. The electrolyte can be an acidic or an alkaline solution, or a solid polymer ion-exchange membrane characterized by a high ionic conductivity. A typical fuel cell uses a solid polymer electrolyte. The solid polymer electrolyte is often referred to as a proton exchange membrane (PEM).

In fuel cells employing liquid fuel, such as methanol, and an oxygen-containing oxidant, such as air or pure oxygen, the methanol is oxidized at an anode catalyst layer to produce protons and carbon dioxide. The protons migrate through the PEM from the anode to the cathode. At a cathode catalyst layer, oxygen reacts with the protons to form water. The anode and cathode reactions in this type of direct methanol fuel cell are shown in the following equations:



The essential requirements of typical fuel cells include: first, the fuel cell requires efficient delivery of fuel and air to the electrode, which typically requires complicated microchannels and plumbing structures. A second requirement is that the fuel cell should provide easy access to the catalyst and a large surface area for reaction. This second requirement can be satisfied by using an electrode made of an electrically conductive porous substrate that renders the electrode permeable to fluid reactants and products in the fuel cell. To increase the surface area for reaction, the catalyst can also be filled into or deposited onto a porous substrate. However, these modifications result in a fragile porous electrode that may need additional mechanical support, such as by use of a fiber matrix. Alternatively, the electrode can be made of an etched porous Vycor glass substrate or an etched-nuclear-particle-track membrane substrate to improve its toughness

1 and strength. A third requirement is close contact between the electrode, the catalyst, and  
 2 the PEM. The interface between the electrode and PEM is a discontinuity area as  
 3 concerns the electric current transmission wherein the charge carriers are the electrons, on  
 4 one side, and the protons on the other side. A solution to this problem has been attempted  
 5 by hot pressing of the electrodes onto the PEM (U.S. Patent No. 3,134,697). Another  
 6 solution suggests the intimate contact of the catalytic particles with a protonic conductor  
 7 before interfacing the electrode with the electrolyte (U.S. Patent No. 4,876,115). Other  
 8 solutions are described in U.S. Patent Nos. 5,482,792 and 6,022,634. A fourth  
 9 requirement is that the fuel cell should provide for humidity control of the electrode. The  
 10 PEM requires water to be effective in conducting protons. However, since it operates at a  
 11 higher temperature than its surroundings, the PEM tends to dehydrate during operation.  
 12 The typical method of re-hydrating the PEM is to capture water in the exhaust stream and  
 13 circulate it back to the PEM.

14 Figure 1 illustrates a non-portable electronic device 1 including a conventional,  
 15 wired power supply. The non-portable electronic device 1 illustrated in Figure 1 is shown  
 16 as a desktop computer. The non-portable electronic device 1 includes a housing 3 in  
 17 which components of the personal computer are maintained, and a power supply 10. The  
 18 power supply 10 includes a device for converting AC power to DC power for subsequent  
 19 supply to components of the personal computer, means for supplying the AC power to  
 20 peripheral devices associated with the personal computer, and a cooling fan (not shown)  
 21 for removing heat generated by the power supply 10. Power is provided to the power  
 22 supply through transmission means 14, which is a conventional AC power cord.

23 Figure 2 illustrates the power supply 10 in more detail. The power supply 10  
 24 includes the AC/DC conversion module 13, cooling fan section 12 and the power supply  
 25 cord 14. As shown in Figure 2, the power supply 10 is built to specific dimensions a, b  
 26 and c. The dimensions a, b and c may be specified as industry standard values for a  
 27 typical personal computer. Other industry standards or criteria for the power supply 10  
 28 may include input voltage and frequency output voltage, location of electrical  
 29 connections, power (watts) generated, limits on heat generated, and other  
 30 criteria/characteristics. In this way, any wired power supply unit may be substituted for  
 31 the power supply 10 shown in Figure 2. The dimensions and other criteria that determine  
 32 the shape and other characteristics of the power supply 10 are here referred to as the form  
 33 factor of the power supply 10.

1 A limitation of the non-portable electronic device 1 shown in Figure 1 is that the  
2 device cannot be operated in any area where electrical power is not readily available.  
3 Furthermore, the device 1 may be designated or designed to operate with power delivered  
4 at a certain frequency or voltage level. The device 1 may not be usable in all  
5 geographical regions, particularly those regions that supply electrical power at  
6 frequencies and voltages that are not compatible with the power supply 10. Thus,  
7 operation of the electronic device 1 may be limited to certain geographical regions,  
8 diminishing its value.

9 To solve this geographical use limitation and other problems inherent in the power  
10 supply 10 shown with the non-portable electronic device 1, a retrofittable power supply  
11 100 having a same form factor as the power supply 10 shown in Figure 2, is provided as  
12 shown in Figure 3. The retrofittable power supply 100 includes a power generation  
13 module 101, a cooling module 103, and a DC/AC generation module 105. As illustrated  
14 in Figure 3, the retrofittable power supply 100 has dimensions a, b and c equal to the  
15 corresponding dimensions a, b and c shown for the power supply 10 in Figure 2. Other  
16 characteristics of the retrofittable power supply 10 may be made to coincide with those of  
17 the power supply 10. Accordingly, the retrofittable power supply 100 may simply be  
18 inserted into the framework or bay normally used to house the power supply 10.

19 In an embodiment, the power generation module 101 may be a fuel cell, or  
20 otherwise incorporate fuel cell technology. The fuel cell may be a proton exchange  
21 membrane fuel cell, for example. Excess water generated by the fuel cell may be held or  
22 disposed of through the power generation module 101.

23 The DC/AC conversion module 105 includes means for converting DC power  
24 generated by the power generation module 101 into AC power for further supply to  
25 components of the non-portable electronic device 1 and as the power supply for  
26 peripherals that may be associated with the non-portable electronic device 1, including a  
27 computer monitor and a printer, for example.

28 The cooling module 103 may be used to remove excess or waste heat generated by  
29 the power generation module 101. In an embodiment, the cooling module 103 may  
30 comprise a cooling fan. Alternatively, the cooling module 103 may be implemented as a  
31 series of fins that provide for radiant heat transfer from the power generation module 101.  
32 Other conventional means of removing waste heat generated by the power generation  
33 module may also be incorporated into the cooling module 103. Finally, the cooling  
34 module 103 may return some waste heat to the power generation module 101, for

1 example, to help with evaporation of excess water retained by the power generation  
2 module 101.

3 Figure 4 is a cross sectional view of the power generation module 100, embodied  
4 as a fuel cell. The power generation module 101 includes a fuel cell 111 and a water  
5 retention mechanism 113. Water retention and disposal means are described in detail in  
6 U.S. Patent 6,057,051, hereby incorporated by reference. The water retention means  
7 include super absorbent polymers such as a polyacrylate cross-link material and a starch-  
8 polyacrylate graphed copolymer cross-link material. Other water retention means may  
9 include a small water tank.

10 Figure 5 shows an alternative embodiment of a retrofittable power supply 120.  
11 The retrofittable power supply 120 includes power generation module 121, power storage  
12 module 123, DC-AC conversion module 127, cooling module 125, and AC power out  
13 connection 129. The power generation module 121 may be a proton exchange membrane  
14 fuel cell, for example. The power generation module 121 may generate DC power that is  
15 subsequently stored in the power storage module 123. Alternatively, or in addition, the  
16 power generation module 121 may provide DC power directly to components of the non-  
17 portable electronic device 1 shown in Figure 1, and provide, in parallel, power to the  
18 power storage module 123. The power storage module 123 may be a conventional  
19 rechargeable battery, for example. Other technology such as a fly wheel device may also  
20 be used in the power storage module 123. Use of the power storage module 123 may  
21 ensure a constant supply of power to the non-portable electronic device 1 during times  
22 when the power generation module 121 is not generating electrical power at a sufficient  
23 rate to supply the components of the non-portable electronic device 1. The DC/AC  
24 conversion module 127 and the cooling module 125 may operate in a manner similar to  
25 corresponding devices shown in Figure 3.

26 In operation, the retrofittable power supply 100, shown in Figure 3, provides DC  
27 and AC power to various components and peripherals associated with the non-portable  
28 electronic device 1, shown in Figure 1. The retrofittable power supply 100 may be  
29 replaced when the power generation module 101 is no longer capable of generating  
30 electrical power. For example, in a power supply in which fuel cell technology is  
31 employed when the fuel available, (e.g., liquid methanol) is exhausted, the fuel cell will  
32 not longer be able to generate electrical power, and the retrofittable power supply 100  
33 may be replaced with a replacement retrofittable power supply having a fully charged fuel  
34 cell. Alternatively, the power generation module 101 using fuel cell technology may

